A high-precision flatness measurement for cryogenic mosaic focal plane arrays

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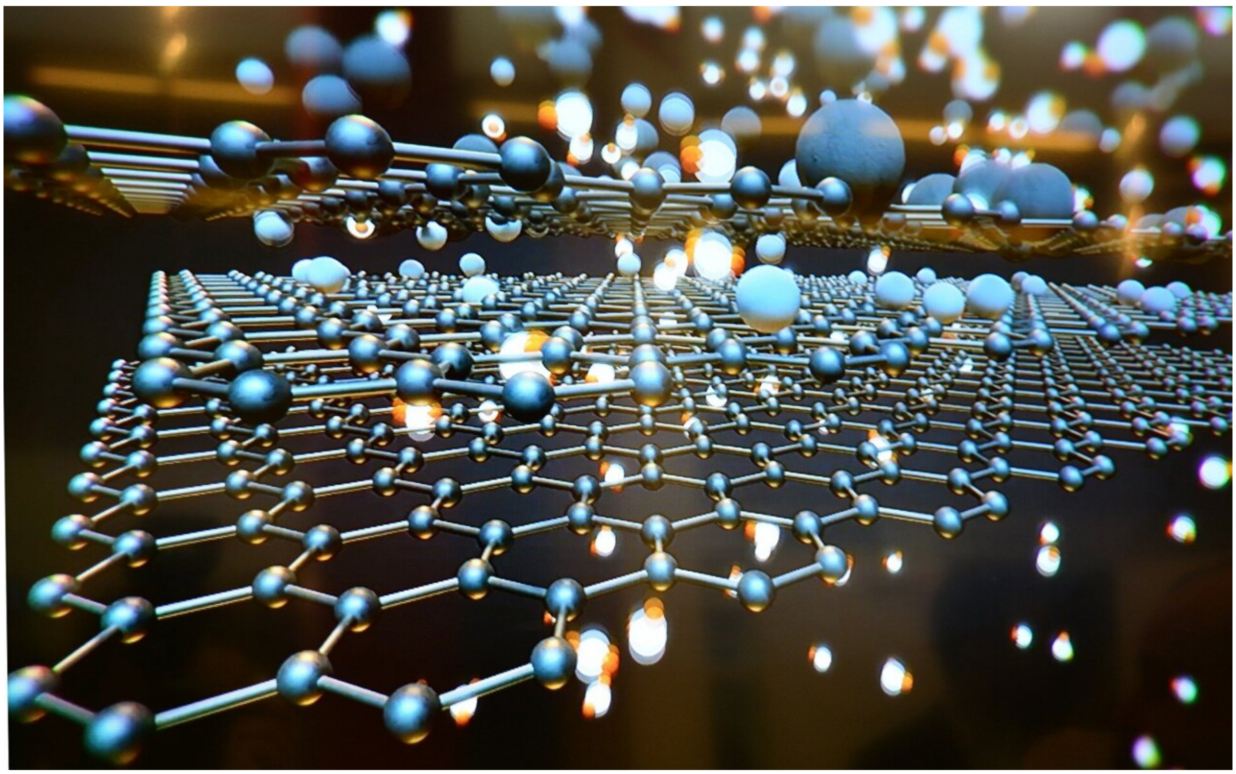

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A research team led by Professor Wang Jian, the deputy chief designer of the Wide Field Survey Telescope (WFST) and a faculty member of the State Key Laboratory of Nuclear Detection and Nuclear Electronics of the School of Physics, University of Science and Technology of

China (USTC) of the Chinese Academy of Sciences (CAS), carried out the key technology of the main focus camera. The results were published in *IEEE Transactions on Instrumentation and Measurement*.

Wide-field cameras are the core equipment of wide-field telescopes. Due to the size limitations of individual sensors, a single sensor cannot satisfy the needs of a large focal plane for wide-field cameras. Consequently, the critical technology in the development of wide-field cameras lies in the mosaic assembly of large-target detectors.

High-precision focal plane arrays require both meticulous fabrication and accurate measurement. Given that detectors typically operate at low temperatures to reduce dark current, measurements need to be conducted at both room and low temperatures. This ensures that the detector maintains excellent flatness under cold conditions, thus enhancing the imaging quality of the detector.

Based on the current developments in astronomy both domestically and internationally, and in line with the growth trends observed in astronomical science and technology, efforts have been made in China to capitalize on the expertise and foundational research of existing research teams.

After years of preparation and accumulation, USTC and the Purple Mountain Observatory of the CAS have jointly proposed the construction of the WFST—a 2.5-meter aperture telescope with the most advanced sky survey capabilities in the northern hemisphere. This endeavor aims to establish a leading position in time-domain astronomical observations.

A pivotal component of the WFST is its large focal plane mosaic main camera. The scientific imaging of this camera is assembled from a mosaic of nine 9K×9K CCD chips, resulting in a designed imaging target surface diameter of D325mm. The surface flatness of the assembled image is less than PV20um. This makes it the largest of its kind domestically and positions it at a world-leading level.

The focal plane mosaic flatness specification for the WFST is exceptionally stringent. A primary challenge in the development of the main camera is addressing high-precision measurements, especially under cold conditions.

The team tackled key technological challenges associated with the primary focus camera. This includes the vacuum cold packaging of the detectors, high-precision measurement and assembly of large-target detectors, low-noise and low-power reading and driving of the detectors, and efficient camera control.

For the high-precision measurement of large target detectors, the team overcame challenges in non-contact measurement of high planarity under cold conditions. They introduced a Differential Triangulation Measurement method, based on laser triangulation, suitable for sensors under low-temperature packaging conditions.

The measurement error under vacuum sealing does not exceed 0.5%, and the repeated measurement accuracy can reach up to ±2μm. Building on this, they completed the development of the DTS measurement instrument and ultimately achieved measurements of the WFST primary focus camera under low-temperature conditions.

The WFST primary focus camera has now been successfully developed and transported to Cold Lake, where it will be installed and integrated with the main body of the telescope for calibration and testing.

More information: Yihao Zhang et al, High-Precision Flatness Measurement for Cryogenic Mosaic Focal Plane Arrays, *IEEE*

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